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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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ANACOSTIA NAVAL STATION
GREENBELT, MARYLAND

INSTRUCTION MANUAL

P - 14 GROUND RECEIVING SYSTEM

(REVISION 1)

Telemetry Systems Section
Radio Systems Branch
Tracking Systems Division

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P-14 SYSTEM

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1.0 Introduction and List of Major Components

The P-14 Ground Receiving System combines features of both the Tunable Telemetry and the Tunable Doppler Systems in one complete package and offers the maximum amount of system flexibility for cross-connecting major components. An interconnection P-14 Block Diagram is shown in Figure 1.

Basically, the A-Rack (see Figures 3 and 4) now contains a Tunable Telemetry system with an R-220 Receiver, Output Converter, 108.000 mc. Insertion Oscillator and a Video Amplifier. The B-Rack contains the Tunable Doppler System with the Doppler R-220 Receiver, Interstate Model VIII Tracking Filter, and Doppler Video Amplifier. Appropriate power supplies are included in both racks.

Several changes in equipment layout in the A and B Racks, as described above, have been made since the P-14 equipment was initially issued to the field stations. One change was the elimination of the FM-6 Insertion Oscillator, and incorporation of a crystal controlled 108.000 mc. Insertion Oscillator (P-14 satellite carrier frequency 108.060 mc). This considerably improves the frequency stability of the system. It was decided, however, to leave the FM-6 Insertion Oscillator and VHF Tunable Amplifier in the racks to provide the field stations with capability for reception of satellite signals other than P-14.

The C-Rack contains the Staircase Converter, the Counter Printer combination for printing out the Doppler data, an oscilloscope and appropriate power supplies.

All of the inputs and outputs of the major components of the two systems are brought out to the Patch Panel at the rear of the B-Rack and a high degree of system flexibility is afforded by various patching combinations as needed. Rapid patching is possible without reference to block diagrams or circuit drawings. Another design feature is the addition of the Test Panel on the front of the B-Rack where significant test points of the two systems are brought out for aid in checking out the systems with scopes and other test equipment in front of the racks. Convenience outlets are installed at the bottom of each rack for plugging in the test equipment.

The tuning range of the P-14 System is from 20 mc to 230 mc in conjunction with appropriate preamplifiers and antennas.

The P-14 System may be used with the satellites or probes using AM, FM or PM crystal-controlled transmitters. The preamplifiers supplied for P-14 are tuned to 108 Mc., but field stations are currently being supplied with preamplifiers tuned for the 136-137 Mc. band.

An "in-house" preamplifier unit furnishes output signals to both R-220 receivers. A pole-mounted preamplifier furnishes an output signal for the "in-house" preamplifier unit (see Figure 2).

Initially, the P-14 receiving system utilized two R-F Hybrids for division of received signals between the Doppler and Telemetry R-220 receivers, and for injection of the Insertion Oscillator signal into the Doppler R-220 Receiver. However, a recent modification to the R-220 receiver permits the injection of the Insertion Oscillator signal directly into the Doppler receiver. This arrangements eliminates both R-F Hybrids previously used. A marked advantage is that the system is now frequency broadband (i.e. operates on 108 mc or 136 mc) and signal reception is not restricted by narrow-band R-F Hybrids.

In summary, the major components of the P-14 System are as follows:

a. Dual unit pole-mounted preamplifier, and single "in-house" unit preamplifier; GSFC designs, contractor constructed; common to both Telemetry and Doppler Sub-systems.

b. Telemetry Receiver, Motorola R-220, Modified.

c. Telemetry Output Converter GSFC design, contractor constructed.

d. Telemetry Video Amplifier GSFC design, contractor constructed.

e. Doppler Receiver Motorola R-220, Modified (modification identical to the Telemetry R-220).

f. 108.000 mc Insertion Oscillator, GSFC design and fabrication.

g. Antenna Polarization Differentation Network Box (to obtain Hor., Vert., Right and Left-hand Cir. Polar.), All Products Corp.

h. Doppler Video Amplifier
(identical to Telemetry Video Amplifier)

i. Tracking Filter, Interstate Model VIII.

j. Oscilloscope, H-P Model 130 BR, for visual aid to lock with the tracking filter.

k. Counter, H-P Model 524C with counter-commutator added.

l. Printer, H-P Model 560-A for Doppler data print-out.

m. Staircase Converter, GSFC design.

n. Audio amplifier, 8 watt, Knight Model KN 3008, and loud speaker, (Common to both Systems).

2.0 Doppler Acquisition System

2.1. Tabulated Specifications (Electrical)

2.1.1. Frequency: 108 mc $\pm$ 1.2 mc (with pole-mounted and "in-house" preamplifiers).

2.1.2. Preamplifier Bandwidths: Dual Unit - 4.2 mc; Single Unit- 3.5 mc

2.1.3. Preamplifier Gain: + 37 db, nominal.

2.1.4. Preamplifier output impedance 50 ohms, nominal.

2.1.5. Preamplifier noise figure: 2.5 db, nominal.

2.1.6. Overall System noise figure: Same as pole-mounted preamplifier with less than 20 db cable loss.

2.1.7. Pre-detection bandwidths: 8kc; 45kc; 70kc; 180kc
These bandwidths are measured values taken between the 3 db points in the R-220 receiver. The selectivity values on the receiver selectivity control are measured between the 6 db points, as specified by the Signal Corps.

2.1.8. Post-detection bandwidth (video amp) $\pm$ 0.5 db between 100 cps and 110 kc, referenced to the response at 1000 cps.

2.1.9. Tracking Filter Input Frequency Range (Doppler) 100 cps to 120 kc.

2.1.10. Tracking Bandwidth: Adjustable 2.5, 5, 10, 25, 50, 100 cps.

2.1.11. Provisions to Record:

a. R-220 detected signal (auxiliary diode or FM discriminator) amplified by video amplifier.

b. Tracking Filter AGC, or Telemetry R-220 AGC.

c. Tracking Filter Doppler output.

d. Tracking Filter demodulator PM Phase Detector output.

e. Tracking Filter demodulator AM Phase Detector output.

f. Audio Commentary from microphone.

g. Coded Time Signal

h. 100 kc and 10 kc Time Signals.

2.1.12 Counter - printer provisions.

a. Count and print normally.

b. Count and print Tracking Filter output (Doppler Difference).

c. Count and print Insertion Oscillator and Doppler frequencies alternately.

d. Count and print Insertion Oscillator frequency, count and add Doppler difference frequency and display and print the sum.

2.2 Telemetry Data Acquisition

2.2.1. The Telemetry sub-system utilizes the same "in-house" pre-amplifier as the Doppler sub-system, with its own R-220 receiver. The Output Converter is normally associated with this receiver as is the Telemetry Video Amplifier, for tape recording these output functions in the normal manner. However, as pointed out in Par. 1.0, the new Patch panel in rear of the B-Rack allows a high degree of intra-system flexibility and components of one sub-system may be cross-patched to the other sub-system in case of component failure or a non-standard system hook-up. For instance, the Tracking Filter may be connected into the telemetry sub-system to use the synchronous demodulation technique inherent in the demodulator section of the filter, to increase the output signal-to-noise ratio at low r.f. signal input levels. This feature will improve the output signal-to-noise ratio in approximately the same proportion as the input bandwidth to output bandwidth ratio in the tracking filter.

The R-220 receiver has the FM discriminator output (maximum of $\pm$75 kc deviation) brought out at the back of the chassis as well as the auxiliary diode. The cables from these two outputs are labeled and either one may be connected into the Video Amplifier.

2.2.2 Provisions to record.

a. R-220 AGC to Sanborn or tape, either single-ended or balanced.

b. Output Converter, R-220 455 kc I.F. translated downward to center frequencies of 7 kc, 25 kc, 52 kc, or 70 kc. Two output channels, one common input.

c. R-220 detected output (auxiliary diode or FM discriminator, amplified by Video Amplifier).

2.3 Theory of P-14 System Operation

This receiving system (see Figures 1 and 2) has been designed to receive 108 mc $\pm$ 1.2 mc (with the preamplifiers supplied) satellite signals, either AM, FM or PM type transmitters, for the purpose of tracking, measuring and recording the Doppler shift and also for recovering telemetering data, simultaneously.

The P-14 probe utilizes a turnstile antenna which transmits circularly polarized waves. Therefore, linearly polarized (vertical or horizontal) antennas should be used for reception. Outputs from the Telemetry R-220 receiver are a 455 kc I.F. signal undetected, and a detected signal, either the auxiliary diode or the FM discriminator. The Output Converter is normally connected to the auxiliary I.F. to translate the frequency downward to any one of four selectable center frequencies for tape recording.

The detected output (Auxiliary Diode) of the Doppler R-220 should be connected to the Video Amplifier for amplification before tape recording.

The selectivity of the Doppler R-220 must be chosen so as to allow the Insertion Oscillator signal to be passed along with the satellite signal. The selectivity setting desired is 200 kc since the 108.000 mc Insertion Oscillator is 60 kc below the 108.060 mc transmitter.

The two signals are processed in the Doppler R-220 receiver and are detected in the auxiliary diode detector where the difference frequency is taken out and applied to the input of the Video Amplifier. The output of the Video Amplifier is then applied to the input of the Model VIII Tracking Filter for tracking and lock-on. The Doppler information is then obtained at the output of the Tracking Filter and is alternately measured and added to the Insertion Oscillator frequency by means of the Counter-Commutator in the 524C counter and the data is printed out by the Digital Printer. Provision is also made to measure the Insertion Oscillator frequency alone, as well as the Doppler frequency alone.

The Tracking Filter contains a demodulator unit which has an AM Phase Detector and a PM Phase Detector, which will demodulate the incoming signal once the Tracking Filter is locked on to the carrier. These outputs can also be recorded on tape.

Other functions of the Tracking Filter which can be recorded on tape are the AGC and the Doppler output. The pre-detection bandwidth of the Tracking Filter is 120 kc and the post-detection bandwidths are 1 kc, 3 kc, 10 kc, 30 kc, and 60 kc, selectable from the front panel.

2.4 System Test and Calibration Procedures:

2.4.1. System Noise Figure:

The noise figure of the system should be 2.5 to 3.5 db with the pre-amplifier mounted at the antenna. Some variations between systems will be noted, since the noise figure of the preamplifier and R-220 receivers will vary. The noise figure of an R-220 in good condition will run 6.5 to 7 db at 108 mc. However, the overall system noise figure is primarily determined by the preamplifier.

2.4.2 Procedure for the Measurement of System Noise Figure:

a. The noise generator is connected to the pole mounted preamplifier and the two receivers are tuned to 108 mc.

b. The receivers are set to manual gain control (MGC) and the noise generator is set to 17 db. Each ANTENNA TRIMMER is tuned to maximize the R-220 output.

c. The 108.000 mc Insertion Oscillator is turned OFF.

d. The output level meter on the R-220 is set to some convenient reference level which we will call point "A" by varying the manual gain control and the audio gain l control. The output meter should be set on the low range. Once the audio control is set, it should not be re-adjusted.

e. The noise output is then increased to 20 db and the output level meter on the receiver will be deflected to point "B".

f. The noise output from the generator is reduced to zero and the manual gain control on the receiver is used to bring the output level meter up to the reference level, point "A".

g. Then the noise output from the generator is increased until the needle on the level meter on the receiver is deflected to point "B".

h. Then the system noise figure is read on the output level meter on the noise generator.

NOTE: To prevent damage to the noise generator, DO NOT leave the output of the noise generator on any longer than is necessary to make the measurement.

2.4.3 Receiver Tune-up and Dial Calibration Procedure

a. A Hewlett-Packard 608 D signal generator is situated so that it will be as free from vibration and shock as possible. It is tuned to 108 mc, cw, as determined by a frequency counter.

b. The 108.000 mc Insertion Oscillator is turned OFF.

c. The 108 mc signal from the 608D is fed through the "In-House" preamplifier into the system with both BFO"s on.

d. With the BFO set at zero, the receivers are tuned to zero beat.

e. Each auxiliary i.f. output is counted. These outputs are available on the Test Panel on the front of the B rack. A model 525A or 525C Frequency Converter, set at the zero frequency position and maximum gain should be used in the counter to assure proper operating level for the counter. Other models of frequency converters will not have sufficient gain.

Switch the R-220"s to MGC position and advance the RF Gain Squelch Controls until sufficient output is obtained to operate the counter. If the i.f. is not 455 kc, the tuning is changed until it is 455 kc. Then change the BFO dial until the zero beat occurs. The position of the BFO dial where the i.f. is 455 kc and the zero beat occurs is the true zero position of the BFO dial. Should the zero position occur at the point other than at the ZERO mark on the panel, an internal adjustment, capacitor C-408, is accessible at the bottom of the R-220 chassis for re-setting, if desired. Reference is made to the R-220 Instruction book, page 82 paragraph 72 which describes the BFO circuit and its operation.

f. The above tuning procedure should be done using the R-220 selectivity called for on the given satellite operation plan, since the sharpness of tuning will vary with bandwidth selected in the R-220.

g. Switch the R-220 back on AGC position.

2.4.4. Output Converter Checks

2.4.4.1. Local Oscillator measurements:

a. Connect a Hewlett-Packard counter to L.O. Test Connector on Test Panel on the front of the B-rack.

b. Switch to each crystal and adjust each L.O. frequency in turn to within ± 10 cps of marked frequency by adjusting the VC-50 capacitor associated with each crystal.

2.4.4.2. Level Setting of Output Converter and Video Amplifier.

a. Apply -80 dbm 108 mc signal modulated 50% at 1000 cps to preamplifier input.

b. Set R-220 on AGC position.

c. Rotate Output Converter output controls to full clockwise position (20 volt point).

d. Connect a Tektronic Scope to Output Converter channel 1 on Test Panel.

e. Adjust INPUT LEVEL potentiometer on converter chassis to give a 20 volt peak-to-peak reading on scope, including modulation. This should be checked for all four local oscillator crystal positions.

f. In the same manner check output converter channel 2 level on scope.

g. Set Video output controls to full clockwise position.

h. Connect scope to VIDEO 1 on Test Panel.

i. Adjust INPUT LEVEL potentiometer on video chassis to give a 10 volt peak-to-peak reading on scope. This is demodulated 1000 cps signal.

j. Check VIDEO 2 on Test Panel for output level.

k. Once the Output Converter and video input levels are set, the output controls can be set to the desired recording level without re-adjusting the input level controls.

2.4.4.3. Output Converter Output Frequency:

a. Remove the modulation from the 108 mc signal. Maintain -80 dbm input level to system.

b. Count the Output Converter frequency on all four local oscillator crystals. These should be 7 kc, 25 kc, 52 kc, and 70 kc. If R-220 is correctly tuned, these should be within ± 500 cps.

2.4.4.4. AGC Adjustments

Two adjustments are available for AGC recording, Single-ended and balanced.

a. Remove 108 mc signal input to system.

b. Connect a VTVM to single-ended AGC connector on Test Panel.

c. Adjust single-ended AGC balance potentiometer on output converter chassis to give zero voltage. This AGC voltage goes increasingly negative with increased signal input.

d. Connect VTVM between Pin- A and C on AN 3102 14S-7S connector on converter chassis, and measure the voltage V_A. Then connect VTVM between pins B and C, and measure voltage V_B.

e. Adjust AGC C.F. Balance control on chassis to make $V_A = V_B$ with zero signal input signal. Pin B goes increasingly positive (with respect to pin A) with increased signal input. This balanced AGC output is available for future use with a Sanborn recorder if desired.

f. After balancing the controls, full AGC calibration should be made for each bandwidth available on the R-220. P-14 normally uses only the single-ended AGC.

2.4.4.5. Tracking Filter and Demodulator

a. The Insertion Oscillator gives an output frequency of 108.000 mc which is 60 kc below the P-14 transmitter frequency (PM) of 108.060 mc.

b. Adjust the output level of the 108.000 mc Insertion Oscillator, using the insertion oscillator pads, to an equivalent level of approximately - 110 dbm, referred to the pole-mounted preamplifier imput (see Figure 2). This level may be set by reference to the AGC calibration curves called for in Paragraph 2.4.4.4. The level of the Insertion Oscillator should remain at -110 dbm. for probe signals of -110 dbm or weaker. Adjust the level to equal signals stronger than -110 dbm.

c. Insert a 108 mc signal, unmodulated, into the pole-mounted preamplifier input at a level of -110 dbm. Set the selectivity control on the R-220 to the 200 kc position.

d. Set the Video Amplifier output level to give an input to the Tracking Filter of 1 volt rms (for manual tracking).

e. Switch the Acquisition control on the Tracking filter to SET and tune the SET FREQUENCY control around an indicated frequency of 50 kc on the frequency meter. The CORRELATION METER will begin to fluctuate near zero beat. At this point, switch the ACQUISITION CONTROL TO MANUAL. If a good lock-on occurs, the CORRELATION METER will read approximately 100.

f. Check the output of the AM Demodulator which is available on the Test Panel on the B rack, with an oscilloscope to see that a good sine-wave is obtained. Aural monitoring with headphones plugged into the phone jack will aid in determining true zero beat with the carrier instead of a sideband.

NOTE: See Paragraph 14.0 for special instructions to insure Tracking Filter lock-on to the carrier in lieu of a sideband frequency.

3.0 108 mc Pre Amplifiers:

3.1 Tabulated Specifications (In-House Unit):

3.1.1.	Center Frequency:	108 mc
3.1.2.	Bandwidth:	3.5 mc (3db points).
3.1.3.	Noise Figure	2.5 db, nominal
3.1.4.	Gain	+37 db
3.1.5.	Input VSWR	6:1
3.1.6.	Output Impedance	50 ohms, Nominal
3.1.7.	Isolation	20 db between outputs

3.2 Power Requirements:

3.2.1. 115 V a.c., 0.5 amps, 50-60 cycles, single phase

3.3 Theory of Operation:

The 108 mc "In-House" preamplifier is a low noise device employing three General Electric 7077 triodes and designed to limit the noise figure of the intended system to 3.5 db, and to permit the use of two receiver systems on the same antenna while providing 20 db isolation between the two receivers. A 50-ohm termination may be connected to the unused output when only one receiver is used.

The unit is housed in a waterproof box, capable of being pressurized and mounted on the base of an antenna, with waterproof power and RF connections. The pre-amplifier has a self-contained power supply and lights on the panel of the waterproof box to indicate that line voltage and dc supply voltage are being supplied.

The first two tubes constitute a cascode circuit and the third tube is a grounded-grid amplifier stage. The input circuit is an autotransfromer which transforms the proper impedance to the input of the first 7077 to obtain minimum noise figure. The output circuit of the second stage is a tuned circuit matching transformer designed to provide the desirable gain and bandwidth characteristics for the overall specifications. The output circuit of the third stage is similar to the output circuit of the second stage except that it matches to 150 ohms, consequently the hybrid power divider is designed for 150 to 50 ohm operation. The first two stages are biased for minimum noise figure operation and the third stage is biased so that output signals of 1 mw are obtainable without overdriving.

3.4 Tuning:

The preamplifier supplied to the stations is tuned up and neutralized before shipment and no adjustment of the unit should be necessary before putting it into operation.

However should it be necessary to change tubes in the preamplifier, the tune-up procedure given below should be followed, in order to insure best gain and noise figure. In case of doubt about the noise figure or sensitivity of the overall r.f. system, including the R-220, the system noise figure should be checked. A nominal overall noise figure of 3.5 db has been set as a maximum limit. Should this figure be exceeded, the noise figure of the R-220 alone should be measured first, since it is the major contributor to the noise. A maximum limit of 8 db has been set for the R-220. Should this figure be exceeded, the r.f. front end of the R-220 will need realignment, since there are no tuned i.f. transformers in the receiver. The R-220 instruction book should be consulted for this purpose.

The following paragraphs give the preamplifier tune-up procedure.

The preamplifier must first be neutralized. To do this, the filament lead to V1 (the input tube) is disconnected and a signal at 108 mc is fed into the Input connector with a detector connected to either OUTPUT 1 or OUTPUT 2. Ln is adjusted to give minimum output. The filament lead is then re-connected.

With the signal generator connected to the input jack and a detector connected to the output, L3 is adjusted to give a maximum output. Next, L2 is adjusted to give a maximum output. This process should be repeated to insure accurate alignment.

The input coil and the tape point is preset for minimum noise figure. However, in aligning the preamplifier if the noise figure measures greater than 3.0 db, adjust C1 slightly until a minimum noise figure is obtained.

The hybrid power divider at the output of the preamplifier is preset for 20 db of isolation and should not be adjusted under normal operating conditions; however, if the isolation between the output terminals is measured and found to be less than 20 db, careful adjustment of the three coils will produce the desired results.

3.5 Operating Procedure:

The housing should be filled with nitrogen, if available, or with compressed air, to prevent condensation. A valve is provided for this purpose and a pressure of two pounds per square inch is recommended.

When the preamplifier is connected to a 115_V ac line, the red light on the left should light up indicating 115_V ac and the red light on the right should light up indicating 250_V dc in the internal power supply.

The type N connector on the left is the signal input and should be connected to the Ant. Polar. Differentiation Network box (see Figure 2) with a minimum length of 50 ohm coaxial cable. Terminals Output 1 and Output 2 are isolated from each other through a hybrid junction. Connection to the R-220 receivers is shown in Figure 2. An RG-9/U coaxial cable length of 50 feet, or less, should be used from the preamplifier to each R-220 receiver .

3.6. Pole-Mounted Preamplifier

A dual unit 108 mc Pole-Mounted Preamplifier has been supplied to the P-14 receiving stations for use as shown in Figure 2. The addition of this unit was necessary since the Antenna Polarization Differentiation Network Box presents a loss of approximately -9 db in the system.

The electrical specifications of the dual unit are similar to the single "in-house" unit with the exception of a broader bandwidth (i.e. 4.2 mc instead of 3.5 mc). In addition, there is no hybrid junction on the output. The gain is made adjustable, however, and the gains should be set equal for a given installation.

4.0 **Insertion Oscillator**

The P-14 receiving system now utilizes a crystal controlled 108.000 mc Insertion Oscillator. Previously the FM-6 was used. The frequency and phase stability of the new unit is superior. In addition, operation is simplified since tuning is not required.

An 0-12 db variable attenuator pad has been included on the panel. The 0-120 db (on VHF Amplifier) and 0-12 db variable attenuator should be cabled in series and brought out to the patch panel at the rear of the "B" Rack. The outputs of the Insertion Oscillator should be cabled to the same patch panel. Low output goes to A7 and high output to A8. Cross-patching can then be made.

4.1 **Tabulated Specifications:**

4.1.1. Frequency Stability:

Long Term: (at constant temperature)
1 part 10^7 for 24 hours

Short Term: 5 parts 10^8 for 15 minutes

4.1.2. Output Levels:

High: 2 milliwatts $\pm$ 1/2 db

Low: -10 dbm

Note: Always terminate high and low outputs with nominal 50 ohm load for proper operation.

4.1.3. Battery Life: Approximately 150 hours of continuous operation.

Note: The field stations should record the high and low output levels upon receipt of the equipment.

The batteries (RCA VS-312 or equivalent) should be replaced when the output power reduces 3 db from the initial level.

4.1.4 Center Frequency: 108.000 mc $\pm$ 1 kc

4.2 Theory of Operation:

The 108.000 mc Insertion Oscillator uses a 108 mc crystal and a type 2N1142 transistor. High and low outputs are obtained by appropriate resistor divider networks.

5.0 Output Converter:

The function of this unit is to convert the undetected 455 kc intermediate frequency of the R-220 receiver to a frequency that can be recorded on the Ampex Tape Recorder.

5.1 Tabulated Specifications: (Electrical):

5.1.1. Maximum output level: 20 volts p-p with less than 5% distortion for 50% AM signal input.

5.1.2. Outputs: dual cathode followers.

5.1.3. Output Impedance: less than 1000 ohms.

5.1.4. Output Level Controls: front panel

5.1.5. Input Level Control: on chassis

5.1.6. Input Level (Nominal): 0.050 V p-p, for 20 v p-p output.

5.1.7. Input Load Impedance: 1000 ohms

5.1.8. Phase Distortion: less than 45° at frequencies less than 120 kc.

5.1.9. Amplifier Filtering: down 50 db at 455 kc.

5.1.10. Passband: 200 cps to 120 Kc., ±1 db.

5.1.11.

Crystal Frequencies	Center Frequencies	Maximum Information Freq.
462 kc ±10 cps	7 kc	6 kc
480 kc ±10 cps	25 kc	24 kc
507 kc ±10 cps	52 kc	51 kc
525 kc ±10 cps	70 kc	50 kc

5.1.12. Internal Local Oscillator:

5.1.12.1. Output voltage 4 v to 7 v p-p (variable)

5.1.12.2. Output Impedance: less than 500 ohms

5.1.13. Power Requirements for Output Converter:

5.1.13.1. 150 volts positive at 50 ma

5.1.13.2. 150 volts negative at 35 ma

5.1.13.3. Heater voltage 6.3 ac at 2 amps.

5.2 Theory of Operation:

A local oscillator generates a signal whose frequency is determined by the choice of crystal. The output of the oscillator is fed to the mixer stage through a cathode follower. The output of the cathode follower also is rectified by a 1N351 diode and filtered by a RC network thereby creating a negative DC bias which is applied to the control grid of the oscillator tube and controls the gain of the oscillator stage. A 5000 ohm potentiometer R151 (or R100A) is provided for manually adjusting the voltage on the grid of the cathode follower. The setting of this pot determines the delay on the AGC line, hence the output level to the mixer converter. The AGC voltage is set to give a 6 volt peak-to-peak signal at the suppressor grid (pin 7) of the mixer tube.

The auxiliary I.F. output of the R-220 is fed through a stage of amplification in the Output Converter mixer. Here the 455 kc auxiliary I.F. of the R-220 is heterodyned with the local oscillator of the converter to generate a lower frequency. A cathode follower and a low-pass filter follow the mixer stage to attenuate the 455 kc signal along with its sidebands. Following the low-pass filter the carrier signal level is down 50 db at 455 kc.

A cathode follower and an LC network (low-pass filter) are employed to peak the signal at 100 kc, and to further attenuate the higher frequencies.

Two outputs of the converter are obtained from cathode followers in order to provide a low impedance source so that the capacitance of the line connecting the output of this unit to the tape recorder does not attenuate the high frequency response.

Provision is made in the AGC section of the output converter for recording the AGC voltage of either one or two R-220 receivers, where diversity reception may be needed at some future time. The AGC output from diode V316 in the R-220 has been opened and BNC connectors installed on the rear of the chassis marked AGC IN and OUT. The AGC output from the R-220 is connected to the BNC terminal on the output converter marked AGC INPUT B. A bridge circuit in the output converter utilizing cathode followers furnishes either a single-ended AGC or a balanced output for recording purposes. The balanced output is taken from between the two cathodes of the bridge network and is connected to an AN3102 14S - 7S connector. The single-ended AGC is taken from one cathode, and a potentiometer marked single-ended AGC on the chassis is provided to adjust the AGC output to zero in the absence of signal.

For diversity operation using two receivers, the individual AGC inputs are connected to AGC INPUT A and AGC INPUT B. These inputs are through 1N351 diodes which conduct only when the cathodes are negative. AGC output A and output B are connected to the respective receiver AGC inputs.

The single-ended AGC output is used for recording on an FM Record amplifier in the Recorder. The balanced AGC output is taken from between the two cathodes of the cathode follower bridge and a potentiometer marked "AGC Cathode Follower Balance Control" is used for balanching the circuit in the absence of signal.

The balanced AGC output is not grounded and may be used with a Sanborn recorder. Pins A and B on the AN3102 14S - 7S connector are used to connect to this output. Pin B goes increasingly positive with increased signal input to the system.

6.0 Video Amplifier:

The function of this unit is to amplify and filter the detected signal from the auxiliary diode or the FM discriminator of the R-220 receiver, thereby obtaining signals having the desired audio frequency to feed into the tape recorder.

6.1. Tabulated Specifications:

6.1.1. Frequency response: 100 cps to 110 kcs ± 1/2 db.

6.1.2. Gain: 14 db.

6.1.3. Output Voltage: 10 v p-p with r.f. signal input to system between -125 and -80 dbm modulated 50% at 1000 cps, R-220 on AGC, and input from R-220 auxiliary diode. R-220 on 10 kc bandwidth.

6.1.4. Input: single-ended to 50 k potentiometer

6.1.5. Input Level: 2.2. v p-p for 10 v p-p output

6.1.6. Outputs: two cathode followers with individual level controls.

6.2 Theory of Operation:

The Video Amplifier takes its input from either the auxiliary diode output of the R-220 or the FM discriminator. The first stage, V1A, is a cathode follower, the output of which is filtered by an RC network. The second stage, V1B, the second half of a 12AT7, is also a cathode follower, the output of which is peaked to about 100 kc by means of an inductive capacitive filter. This output is fed to the grid of a triode, V2A, which utilizes feedback. The output of V2A is split two ways into the input of two cathode followers each having its individual input level controls.

The overall response of the amplifier extends from 100 cps to 110 kc, $\pm$0.5 db, referenced to the response at 1000 cps. B+ and bias voltages are 150 volts and current drain is 25 ma in each case.

The output level of the Video Amplifier, when connected to the FM discriminator of the R-220, will depend directly on the amount of frequency deviation used in the satellite FM or PM transmitter. Measurements made using 6 kc and 15 kc deviation at 1000 cps rate showed output levels of 0.9 volt and 2.4 volts peak-to-peak respectively.

6.3 Video Amplifier Tests:

a. Apply a 1000 cps input signal at 2.2 volts peak-to-peak (0.77 V rms) to the input. Turn input level control to full clockwise position.

b. Set output controls to full clockwise position.

c. Measure the output voltage on an oscilloscope. This should be at least 10 volts peak-to-peak (3.5 V rms minimum).

d. Check the frequency response, keeping constant input level to 2.2 volts peak-to-peak. The response should be flat within $\pm$0.5 db between 100 cps and 110 kc. The response should be down 1 db at 125 kc and 3 db down at 134 kc.

7.0 Model VIII Tracking Filter:

The P-14 receiving stations shall utilize the Interstate Model VIII Phase-Lock Tracking Filter only. Location of this unit, including power supply chassis, shall be as shown in Figures 3 and 4.

The "Operating and Maintenance Manual for Model VIII Phase-Lock Tracking Filter (M-187)" should be consulted for detail instructions on alignment, servicing, etc.

The Model VIII unit shall be connected in the P-14 system, as shown in Figure 1, on the output of the Doppler Video Amplifier.

The Model VIII unit, in an optimum system, will permit "lock-on" acquisition of signals as low as -140 dbm. It should maintain phase-lock at carrier power levels less than -150 dbm.

A 108.060 mc Phase Modulation Calibrator, to simulate the P-14 transmitter, will be supplied to each P-14 station. This unit should be used to compare the P-14 station performance with the following expected signal levels vs range. This table is based on the following assumptions:

Transmitter Power = 2 watts

Receiving Antenna Gain = +23 db (above isotropic).

Transmitter Antenna Gain = 0 db.

Range (Statute Miles)	Received Signal Level * (DBM)
1,000	-82
2,000	-88
4,000	-94
8,000	-100
16,000	-106
32,000	-112
64,000	-118
128,000	-124
Moon	-129
256,000	-130

* This is an optimistic value since -10 db may be added due to unfavorable vehicle antenna aspect, receiving antenna aiming error, etc.

7.1. Tabulated Operational Specifications:

The Model VIII unit should be aligned just prior to use. At least 1 hour should be allowed for the unit to stabilize prior to alignment.

The following Model VIII specifications and settings shall be used for P-14:

7.1.1. Input Voltage Level:
Approximately 1.0 volt rms

7.1.2. Type Tracking: Manual Acquisition.

7.1.3. Tracking Bandwidths:
(see Section 14.0)

7.1.4. Phase Modulation
Cutoff Frequency:
60 kc setting for P-14 modulation frequencies of 30 kc to 60 kc. Use 30 kc setting for modulation frequencies of 30 kc or less.

7.1.5. AGC Setting: Fast.

7.2. Modifications:

The Model VIII Tracking Filter chassis has been modified to provide a "drop-lock" indication by elimination of the 7th digit on the HP 560 - A Printer. The 7th digit is present when the Tracking Filter is locked, and absent when unlocked.

A 1.1 megohm resistor and 250 Kohm potentiometer were added to the Model VIII Filter chassis (Instruction Manuals corrected accordingly). This circuit maintains proper 7th digit voltage for the staircase to print a blank under "drop-lock" conditions.

8.0 Counter-Commutator and Modifications to Hewlett-Packard Model 524C Counter

8.1. Two modifications have been incorporated in the Hewlett-Packard Counter which control its operations for a special purpose.

The counting and display periods are now controlled externally by means of the 1 PPS pulse from the Staircase Converter. This pulse also synchronizes the counting and display periods with the Time Standard giving us a $\pm$ 1 millisecond sync. with WWV on the Doppler data points. The switch on the front panel allows the Counter to be controlled either internally (norm) or externally (gated).

When this switch is in the gated position the Frequency Unit switch on the counter is disabled. The new Time Standard provides the 1 PPS pulse for gated operation from the Signal Distribution chassis. To make it perform properly, a slight modification of the counter was necessary. In the schematic for the Hewlett-Packard 524C modification for external gating, two resistors (100 K and 330 K) were connected as shown. This allows the counter to operate directly from the 1 PPS 6-4 wave of the Signal Distribution Chassis. It also allows the counter to be operated from any other 6-4 wave from this chassis if the need should arise.

8.2 The second modification is the addition of a small chassis (counter commutator) which allows four different counting combinations of two different frequencies:

1. Hi Freq. (from front panel)
2. Lo Freq. (from back panel)
3. Hi Freq. (reset - Lo Freq. - reset)
4. Hi Freq. (no reset - Lo Freq. (added) - reset)

The High Frequency will be the Insertion oscillator frequency. The Low Frequency will be the output of the Interstate Tracking Filter. The Fourth position, the addition of both frequencies, will be the frequency of the Insertion Oscillator plus the Doppler shift.

The Commutator operates from the output of V207 Pin 5. This output is taken through a 100 K resistor, located near Pin 5, to minimize loading effects on V207. The output is then differentiated and the positive portion clipped. The negative triggers a binary which operates at one-half the frequency of V207. Pin 1 of the binary controls the relay and the thyratron. The relay is used to select the proper input frequency to be counted. The Thyratron is controlled in the fourth switch position to allow the two frequencies to be added. In the first three positions this is not needed and the thyratron grid is grounded. The relay operates 1 sec. before the count is started (duringa display period) allowing ample time for it to make contact and not in any way affect the count.

A test point is provided as a check on the output of the relay control cathode follower. The cathode should operate between "0" VDC and -40 VDC. The 25 k potentiometer is provided to adjust this voltage. The need for adjusting is to make sure the relay is completely deactivated at 0 VDC; if zero $\pm$ 5 VDC is not achieved, the relay may stay activated.

The counter should be controlled externally by the 100 kc standard frequency rather than internally.

This unit can be used as a standard counter by leaving the 1 PPS switch in normal position and the switch on the back placed in position number 1.

9.0. Digital Clock

9.1. Theory of Operation

This unit is the new Digital Clock which is a part of the new Time Standard System scheduled to be installed as part of Minitrack Mod I at your station. You are receiving this unit early so that it may be used with your Doppler system of which it is an integral part. For the present, this chassis should be placed near the Doppler system but eventually it will be located in its proper place in the Time Standard Rack.

The unit provided is a Bendix product but the schematic is that made for our prototype. It is not correct in all respects, but should be adequate to aid in installing and understanding this chassis.

This unit will derive its 1 PPS from the Staircase Converter Output. The display will be time of Day in hours, minutes and seconds. Besides the normal serial Analog Time Code Output J7, this unit brings the plates of each binary out through Cathode followers on J1 and J2, containing all the plate signals. A 12-foot cable is provided to connect these outputs to a jack on the Staircase Converter Chassis.

Lever Switch, S-1, on the right side of the chassis is used for setting the clock. Both 100 PPS at J4 and 1000 PPS at J6 are used. These frequencies will not be easily obtained in this temporary installation. Lever switch, S-3, on the left side of the chassis is used to adjust the serial decimal time code, (present code) which is displaced on the Sanborn Recorders. This function will not be used until the new Time Standard System arrives and is permanently installed at the site.

A power cable is being provided to operate this chassis. Since this is not a permanent installation, no power supplies will be furnished.

The power requirements for theDigital Clock chassis are:

+300 VDC	160 ma
-200 VDC	10 ma
6.3 VDC	12 AMPS

10.0. Staircase Converter

10.1. Theory of Operation

This unit is used to derive staircase voltages from the 20 wire output of the new Digital Clock. These staircase voltages are then used to print time of day information on the output of the Hewlett-Packard 560A Printer.

A circuit is also provided for producing a 1 PPS pulse capable of driving both the Digital Clock and the "Gated" position of the 1 PPS switch on the Hewlett-Packard 524 C Counter. The input to this circuit will come from a 50 ohm line to the Minitrack trailer.

When the new timing system is installed, the 1 PPS circuit in the Staircase Converter Chassis will not be used. The 1 PPS signals will then come directly from the new Signal Distribution Chassis to the input jack on the Hewlett-Packard 524C.

The staircase outputs are connected to the Hewlett-Packard Printer to give only the minutes and seconds of the time of day information. Provisions have been made to include the hours at a later date.

The cable link between the Hewlett-Packard 560A Printer and Hewlett-Packard 524C Counter is interrupted by this chassis as a means of applying the time of day information. The large AN connector on the top left should be connected to the Hewlett-Packard 524C Counter by means of the standard cable already provided with your system.

10.2 Adjustment Procedure

A potentiometer adjustment is provided on each staircase output so that the proper D.C. levels can be transmitted to the Hewlett-Packard Counter. The best way to make this adjustment is to set a "zero" on the Digit of interest and adjust for the proper print at the Hewlett-Packard 560A Printers. When this digit is correct, change the Digital Clock to a "nine" or a "five" and readjust if necessary. It may take several cycles for the proper setting.

The time of day information will be printed on the first four columns of the left side of the printer. The remaining seven columns will contain frequency information. The first column on the right will correspond to the first decade on the right side of the Hewlett-Packard 524C Counter.

10.3 Power Requirements

All B+and B- power is provided through the signal cables from both the Hewlett-Packard 560A Printer and the Hewlett Packard 524C Counter.

Filament current will have to be supplied through the AN connector provided (approximately 2 amps at 6.3 VAC). A cable has been provided.

A schematic is provided showing the cabling between these three chassis (Printer, Staircase Converter and Counter).

10.4. Modifications:

A modification of cabling to the staircase converter has been made on certain equipments shipped to the field. The remaining stations should modify equipment as follows:

a. Mount AN-3102A-10SL-3P connector on staircase converter.

b. Remove 7th digit wire from connector AN-3102A-22-14S (Pin G) and connect to AN-3102A-10SL-3P (Pin A).

c. Add wire from 3102A-10SL-3P (Pin C) to AN-3102A-22-14S (Pin G). Also, ground Pin B of AN-3102A-10SL-3P.

d. Add a 2 conductor shielded cable from the Model VIII Tracking Filter to the staircase converter. Following connections are made.

AN-3106 (3108)-10SL-3S		AMPHENOL 165-34
Pin A..................	to..................	Pin D
Pin B..................	to..................	Pin E (shield braid)
Pin C..................	to..................	Pin A

11.0 Hewlett-Packard 560A Printer

Provision has been made in the Printer to indicate loss of lock in the Interstate Tracking Filter by dropping the seventh digit on the printed paper readout. This is done in conjunction with the CORRELATION RELAY in the Model VIII Tracking Filter and when a drop-out of lock occurs, the seventh digit position (reading from right to left) will be vacant. The time code read-out on the paper will remain printed so that the time of drop-out will be known. The seventh digit position is the megacycle figure of the High-Frequency counter read-out.

This unit will also provide the B+ (300 VDC) for the staircase converter chassis.

12.0. R-220 Receiver Modifications

The following modifications to the R-220 were made to improve operation and flexibility.

12.1. Removed 51 ohm Resistor R402 from auxiliary IF output.

12.2. Removed .015 MFD Capacitor C399 and C393 from Pin 7 of V318 and V319.

12.3 Removed 2 white wires from Capacitor side of R379 and connected to blank terminal on Terminal Board. Ran white wire to BNC connector which must be mounted on back of Chassis for AGC input. Brought white wire from R379 to BNC Connector mounted on rear of Chassis, for AGC output.

12.4. Removed 100 MMF C403 from Pin 7 of V320.

12.5. Installed 70 kc Bandpass Filter as per Motorola Diagram. Included switch on rear of chassis so 50 kc or 70 kc bandpass can be used.

12.6. Installed new cyrstal in 2nd L.O. 26.1267 Mc.

12.7. Installed new National Vernier Dial and mount.

12.8. Put 47 K Resistor on Plates of V318 and V319.

12.9 Removed wire from Plug D105 terminal 15 to open supply to heater in RF Head.

12.10. The AGC Bus to switch 303, section 2 front, runs to terminal 6 to provide AGC action when operating on FM position. The wire normally on terminal 6 was taped and left floating.

12.11. Brought out the FM discriminator output to BNC Connector at rear of chassis. Disconnected C356 from output of discriminator to increase frequency response.

12.12. Addition of an assembly which consists of a UG-492B/U feed through connector, UG-88D/U connector and cable, 510 MMF capacitor, and a test socket adaptor Model TVS-1. Removal of miniature V115 and the 5 mc crystal are required. This modification is necessary for injection of the Insertion Oscillator signal into the Doppler R-220 receiver.

13.0 Installation Instructions for Stations Getting P-14 Receiving Systems.

Since initial production of the P-14 Receiving Systems, laboratory checks of a P-14 transmitter package at Goddard Space Flight Center have shown that undesirable phase-noise modulation effects, inherent in the R-220 receiver, can be minimized to an acceptable level if certain precautions are taken.

Originally, the system was designed to have the Emcor A and B racks bolted together, and the C rack separated from the B rack by 1 to 3 inches. It was found that the vibration introducted from the C rack, by the operation of the Digital Printer, was minimized in this manner.

Initially, it was found that the overhead exhaust fans in the racks contributed somewhat to the phase-noise problem. As a result, it was planned that the fans in the A and B racks be unplugged just before the beginning of a satellite passage.

However, a recent investigation indicates that the Interstate Model VIII Tracking Filter can detune, and hence "drop-lock", in a relatively short time due to internally generated heat developed in the B rack when the exhaust fan is "off". As a result, it was decided to move the Tracking Filter chassis closer to the exhaust fan (see Figure 4).

It has been determined that the exhaust fan in the B rack, containing the Tracking Filter, can be left running without detrimental effects. However, it is necessary that the A and B racks be unbolted, and separated by 1 to 3 inches. Now, all three racks (A, B, and C) are separated. The B rack exhaust fan should be left running continuously to keep the temperature of the Tracking Filter to an acceptable level. The exhaust fan in the A rack should be unplugged just before beginning to record data from the Telemetry R-220 receiver. The C rack fan may be left running continuously.

13.1. Detailed Instructions for Installation:

a. Mount A, B, and C racks on concrete floor (in-line).

b. Viewed from the front of the racks, (see Figure 3 or 4), remove the following:

Right side panel of A rack; left and right side panels of B rack; and Left side panel of C rack.

c. Plug in the appropriate cross-connect power and signal cables. Leave some slack in all cables to insure that vibration will not be transmitted between racks.

d. Space the B rack 1 to 3 inches from the A rack, and space the C rack 1 to 3 inches from the B rack.

13.2. <u>Phase Noise Measurements in the P-14 System</u>

13.2.1. The following procedure should be used to measure phase-noise in the P-14 system. It should be utilized on first installation of the system, and checked periodically.

13.2.2. Detailed Instructions:

a. Set up the system for Normal Doppler operation. Have a Techtronix 535 scope and Dukane Calibrator available.

b. Turn the AM and PM phase demodulator output controls fully clockwise on the Model VIII Tracking Filter.

c. Connect the auxiliary I.F. output of the Doppler R-220 receiver to the input of the Output Converter

d. Connect one output channel of the Output Converter to the input of the Tracking Filter.

e. Turn off the 108.000 MC. Insertion Oscillator.

f. Feed a 108 Mc (54.000 setting) unmodulated signal from the Dukane calibrator into the system and tune the R-220 carefully to get a measured 455 kc auxiliary I.F. at the connector on the Test Panel. Switch the R-220 meter switch to the CARRIER position, R-220 on AGC.

g. Adjust the input signal level to give some given carrier reference level on the panel meter. Note this reference level and also the signal generator output level, <u>in dbm.</u>

h. Remove the Dukane input signal and turn on the Insertion Oscillator. Adjust the insertion signal level with the insertion oscillator pads, to give the same R-220 carrier reference level noted in Step (g). Note the setting of the Insertion Oscillator pad.

i. Reapply the Dukane signal input leaving the Insertion Oscillator signal run. Adjust both input levels to give the same dbm settings noted in Steps (g) and (h). At this point, the two input signals are equal in amplitude.

j. Observe the output of the Output Converter channel on the oscilloscope and adjust the output level to give a 3 volt peak-to-peak signal. The output signal should resemble a 100 percent amplitude-modulated signal. If this condition is not obtained, readjust the Insertion Oscillator signal level as closely as possible to simulate the 100 percent condition. In general, the signals will be different by about 1 KC which can be monitored with the Knight Audio Amplifier.

k. Vary the Tracking Filter SET FREQUENCY control and lock on to one of the two signals present in the filter. Check for two different lock-on positions on the filter frequency dial. When two signals are present, the difference frequency will represent a reference phase signal. Record the peak-to-peak voltage on the oscilloscope. This simulates $\pm 90^{o}$ phase-shift.

l. Turn off the insertion signal. If the Tracking Filter unlocks, relock on to the Dukane input signal and record the peak-to-peak voltage at the phase-detector output of the demodulator. A low-frequency random pattern will be observed on the oscilloscope. This is the actual phase-noise of the system.

m. The sine of the angle whose ratio is the peak-to-peak phase noise voltage divided by the peak-to-peak reference voltage (from step k) is the phase-noise in degrees. Calculate and record this figure for future reference and comparison with future measurements to determine system deterioration.

A sample calculation of the phase noise voltage is given below. Assume measured peak-topeak phase noise is 1.0 volts and peak-to-peak reference voltage is 2.9 volts.

$$\sin \emptyset = \frac{1.0}{2.9} = 0.344$$

$$\emptyset \text{ degrees} = \pm 20^{o}$$

A maximum upper tolerance for phase-noise has been set at ±30° for the P-14 Systems.

If this value is exceeded, the R-220 receiver will need repair or adjustment. The respective instruction manual should be consulted for this purpose.

n. Both R-220 receivers in the P-14 System should be tested in the above manner.

14.0 P-14 Precautions to Insure Positive Tracking Filter Lock-on to Carrier Frequency Instead of Side-Bands.

The Interstate Model VIII Tracking Filter which is required in the P-14 Systems, has undergone laboratory tests to determine operational characteristics. It has been found that some practice on the part of the operator is necessary in order to become proficient in the use of the equipment. It is possible to "lock-on" to a side-band of the transmitted signal, instead of the carrier, which is undesirable. This effect is more prevalent when low-frequency modulation is used, where the side-bands are closer to the carrier, than with the higher modulation frequencies.

In the case of P-14, which uses square-wave envelope modulation (the envelope contains variable-frequency square wave information) on a phase-modulated transmitter , proper lock-on to the carrier is critical. For this reason, the following procedure is suggested:

Carrier lock-on should not be difficult for signals that modulate the carrier above 1,000 cps. In this instance, the normal procedure for using the Tracking Filter should be followed.

Since the carrier is phase-modulated, several side-bands will be displayed as lock-on positions. Because of the degree of modulation, there will be two predominant side-bands approximately equal to the carrier in amplitude. Therefore, care must be taken to assure lock-on to the carrier and not the the side-bands. A simple check is to look at the output of the PM Demodulator for well defined square waves after lock-on to the carrier rather than side-bands. Above 50 kc, the square waves will not be well-defined, since the upper cut-off frequency of the low-pass filter in the demodulator is 60 kc.

For signals modulating the carrier below 1,000 cps, the side bands will approach the carrier, making it more difficult to distinguish the carrier from the side-bands. Greater difficulty is experienced at the lower frequencies.

The following procedure will alleviate ambiguity during the square wave modulation period. As the Tracking Filter is tuned by varying the set frequency control, three zero-beats (1 carrier and 2 predominant side bands), with corresponding lissajous patterns, will be displayed on the oscilloscope. The zero-beats can also be detected audibly through the PA System.

One type lissajous pattern is characteristic of the carrier prior to lock-on (see Figure 5-A). The pattern characteristic of a side-band (upper or lower) is shown in Figure 5B. This typical example was made at a modulation square wave f requency of 700 cps. Other modulation frequencies have similar patterns.

The patterns after lock-on for the carrier and side-band frequencies are shown in Figures 5C and 5D at a modulation frequency of 10 cps.

After lock-on to the carrier signal, the PM demodulator signal should be observed for predominance of square waves (see Figure 5E). Lock-on to a side-band frequency (see Figure 5F) does not give a square wave pattern.

As the frequency of the satellite modulating signal decreases below approximately 200 cps, lock-on to the carrier signal becomes more difficult due to the lower modulating frequency and the lower signal level.

Below 200 cps, the Bandwidth setting on the Tracking Filter must be adjusted so that the frequency of the satellite modulating signal is at least 4 times the bandwidth setting in cps.

For example, at 100 cps modulation the bandwidth switch must be set at 25 cps.

15.0. Additional Notes:

The 100 sec. magnetometer modulation (when airborne commutator is on that channel) should appear as a square wave, when proper carrier lock-on is obtained, on the output of the Tracking Filter PM Demodulator.

15.2. Use direct-record amplifier on the Ampex recorder for magnetometer square-wave modulation of 500 cps or higher. Below 500 cps use "FM Record" amplifier in the recorder.

15.3. The following table represents approximate limits of Rubidium 87 Magnetometer modulation frequencies vs. satellite altitude which will be helpful in setting the Tracking Filter.

RUBIDIUM 87 MAGNETOMETER FREQUENCY

Satellite Altitude (statute miles)	Possible Lower Limit	Possible Upper Limit
1,000	75,000 cps	190,000 cps
2,000	40,000	140,000
3,000	25,000	60,000
4,000	18,000	45,000
8,000	5,000	14,000
12,000	2,000	6,000
16,000	500	4,000
20,000	50	2,500
30,000-60,000	15	1,500
60,000-200,000	15	300

15.4. A Linear Mixer has been added (see Figure 2) for simultaneous recording of the 10 Kc and 100 Kc Time reference signals on one recorder channel. It consists of a resistance mixer-divider network, and individual potentiometer controls are provided for adjusting levels. The 10 Kc signal level should be about 30% of the 100 Kc voltage level. The total signal from the Linear Mixer should be adjusted to approximately 3 volts peak-to-peak.

16.0. P-14 System Checkout Procedure:

The P-14 system utilizes components of the Tunable Doppler/ Telemetry equipment. A complete set of equipment for certain stations was manufactured, tested and shipped from a common source. Additional sets of equipment, for other field stations, were obtained by using existing equipment in the field augmented by partial shipments from the manufacturer.

The following P-14 System checkout procedure was used by the manufacturer to check out complete P-14 systems prior to shipment.

It is recommended that each P-14 field station perform the checkout procedure, and record data indicated in the blank spaces. This testing is desirable to determine deterioration as a result of shipment, and to obtain data on equipment sets assembled in the field for the first time. One copy of the checkout procedure should be retained with the equipment, and a second copy forwarded to:

NASA - Goddard Space Flight Center,
Radio Systems Branch
Telemetry Systems Section 523.3.

APPENDIX 1.

P-14 CHECKOUT DATA

System Serial No.______________________

Preamplifier Serial No.________________ or NASA No.__________________

Freq. 108 Mc.______________ 136 Mc. ____________________
(Check One)

Knight Audio Amplifier, Ser. No.__________ or NASA No.__________________

Output Converter Ser. No.__________ or NASA No.__________________

R-220 Receiver Ser. No.__________ or NASA No.__________________

Video Amplifier Ser. No.__________ or NASA No.__________________

EMC 224 Power Supply Ser. No.__________ or NASA No.__________________

EMC 224 POWER Supply Ser. No.__________ or NASA No.__________________

Insertion Oscillator Ser. No.__________ or NASA No.__________________
Amplifier (New GSFC design, when installed in system)

EMC 232A Power Supply Ser. No.__________ or NASA No.__________________

Sorensen Line Regulator Ser. No.__________ or NASA No.__________________

Nobatron DC Power Supply Ser.No.__________ or NASA No.__________________

Video Amplifier Ser. No.__________ or NASA No.__________________

R-220 Receiver Ser. No.__________ or NASA No.__________________

Tracking Filter, Model VIII Ser. No.________ or NASA No.__________________

Insertion Oscillator, FM-6 Ser. No.________ or NASA No.__________________

Digital Clock Ser. No.__________ or NASA No.__________________

HP 130BR Scope Ser. No.__________ or NASA No.__________________

APPENDIX 1. - Continued

HP 560A Printer	Ser. No. ______________	or NASA No. ____________
Staircase Converter	Ser. No. ______________	or NASA No. ____________
HP 524C Counter	Ser No. ______________	or NASA No. ____________
VHF Tunable Amplifier	Ser. No. ______________	or NASA No. ____________

TEST CONDITIONS:

a. Equipment on concrete floor.

b. Separate "A", "B" and "C" racks from each other

c. Turn rack over - head fan "off" in "A" rack during tests. "B" and "C" rack fans to be left running.

1. Apply power. Turn on all a.c. line switches. Set Sorensen line regulator voltage to give regulated output voltage of 115 volts with both R-220 receivers plugged into the regulated output and turned on.

Plug in the preamplifier and connect both outputs (see Figure 2). Allow 30 minute warm up of the complete system (with overhead fans on).

2. Adjust EMC 224 Power Supplies to give +150 volts and -150 volts using coarse and fine controls on the front panels.

3. Set up Tektronix 535 Scope and calibrate both scope preamplifier channels. Set up PRD Noise Generator and HP 608D Signal Generator.

4. Conduct System Test and Calibration procedures in accordance with the P-14 Manual beginning with paragraph 2.4. Set Meter switch on Telemetry R-220 to the CARRIER position. Check for possible "birdies" from Output Converter oscillator (all four crystal positions) in R-220 receivers. Check R-220 receivers for crystal "birdies".

5. Measure and record overall System Noise figure at 108 Mc. for Telemetry R-220 and Doppler R-220.

TEST CONDITIONS - Continued

Record System N. F. (Telemetry)____________________db.

Record System N. F. (Doppler)____________________db.

Record Noise figure of each R-220 alone at 108 Mc and 136 Mc.

Record Telemetry R-220 N. F.__________db (108 Mc.)________db (136 Mc)

Record Doppler R-220 N. F.__________db (108 Mc.)________db (136 Mc)

6. Perform Receiver tune-up and dial calibration in accordance with Paragraph 2.4.3. of P-14 Manual.

7. Perform Output Converter checks in accordance with Par. 2.4.4. Set input levels of Output Converter and both Video Amplifiers in accordance with Par. 2.4.4.2. Measure Output Converter output frequencies in accordance with Par. 2.4.4.3.

8. Perform AGC adjustments in Output Converter for the Telemetry R-220 in accordance with Par. 2.4.4.4.

For Doppler R-220 AGC, connect a high impedance voltmeter to the Doppler Receiver AGC connector on the Patch Panel to be able to calibrate and read this AGC function.

Record Single Ended AGC voltage on Telemetry R-220 and Doppler R-220 AGC for r.f. inputs to system.

Input dbm	Telemetry R-220 AGC Volts	Doppler R-220 AGC Volts
-125		
-120		
-110		
-100		
- 90		
- 80		
- 70		
- 60		

TEST CONDITIONS - Continued

9. Connect the HP 608D to the Preamplifier and test sensitivity of P-14 system by varying with attenuator the 108 Mc. r-f power into the preamplifier. The sensitivities of the Telemetry and Doppler channels shall be checked separately. The following parameters apply:

a. Telemetry Receiver Channel

Noise level (70 K_c bw): -125 dbm. Measured Noise Level ________ dbm.

The Output Converter output shall be checked for ability to receive signals approaching noise level of -125 dbm.

b. Doppler Receiver Channel

The Tracking Filter Model VIII shall be used. Ability to "lock-on" to signals shall exist at -135 dbm (including preamplifier). A good system will maintain lock-on to a Dukane calibrator, down to approximately -150 dbm, which may be substituted for the HP 608D.

Ability to Lock-on to HP 608D ______________ dbm.

Ability to Lock-on to Dukane Cal. ___________ dbm.

Ability to Lock-on to 108.060 MC Phase Modulation Calibrator ______________ dbm.

Reference Voltage: volts p-p

Phase Noise: volts p-p

Sin θ_n = ________________

$\therefore$ θ_n = $\pm$ ________ degrees

10. Check operation of the counter-commutator in all four modes, with Switch at rear of 524 Counter. See Par. 8.1. and 8.2. of P-14 Manual.

11. Location of checkout:

Field Station ___________________________

TEST CONDITIONS - Continued

12. Remarks: Component Discrepancies, Failures, Operational difficulties, etc.

13. Test Engineer/Technician Performing Check-out

____
(signature)

Date: ______________________________

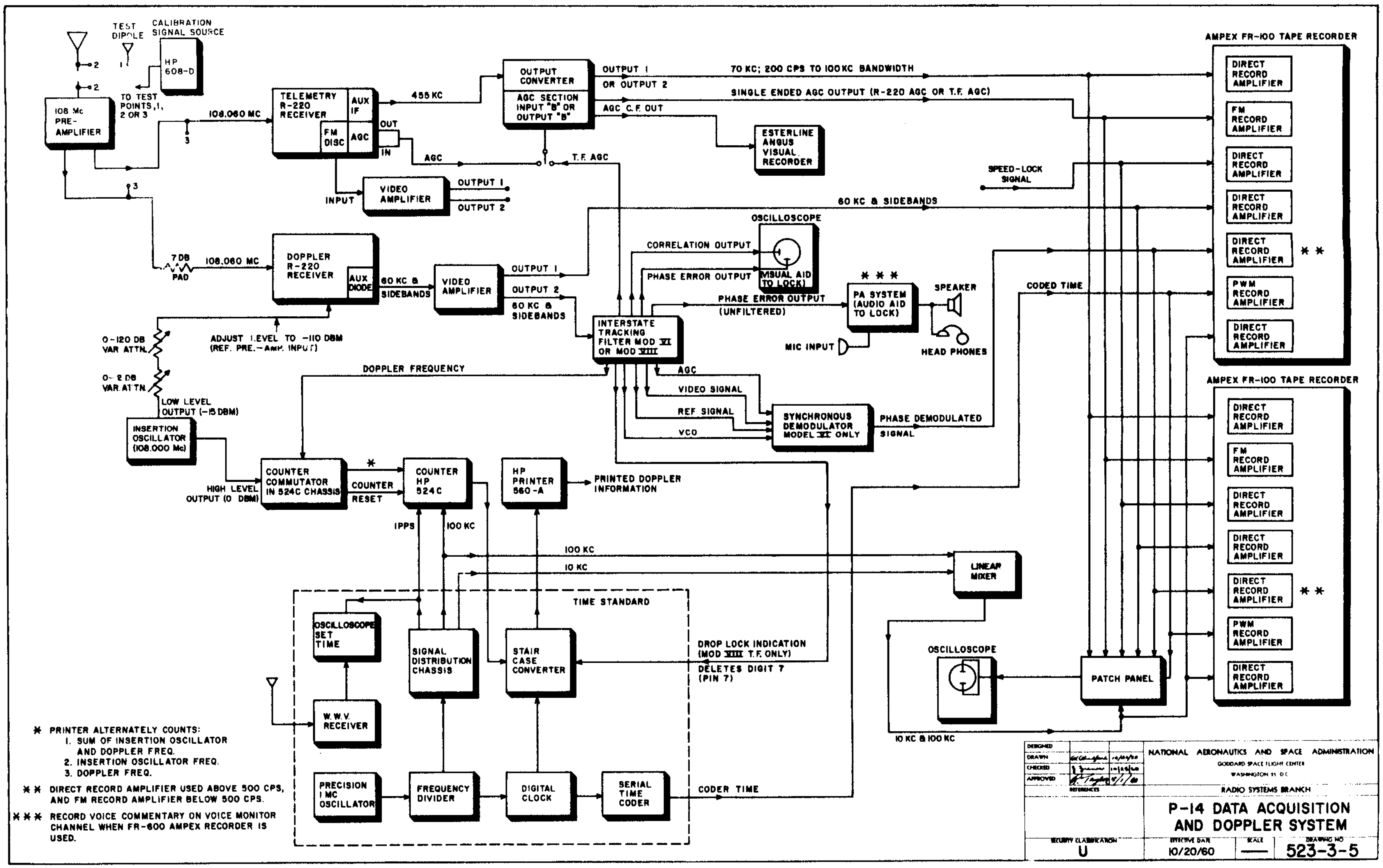


Figure 1. P-14 Data Acquisition and Doppler System

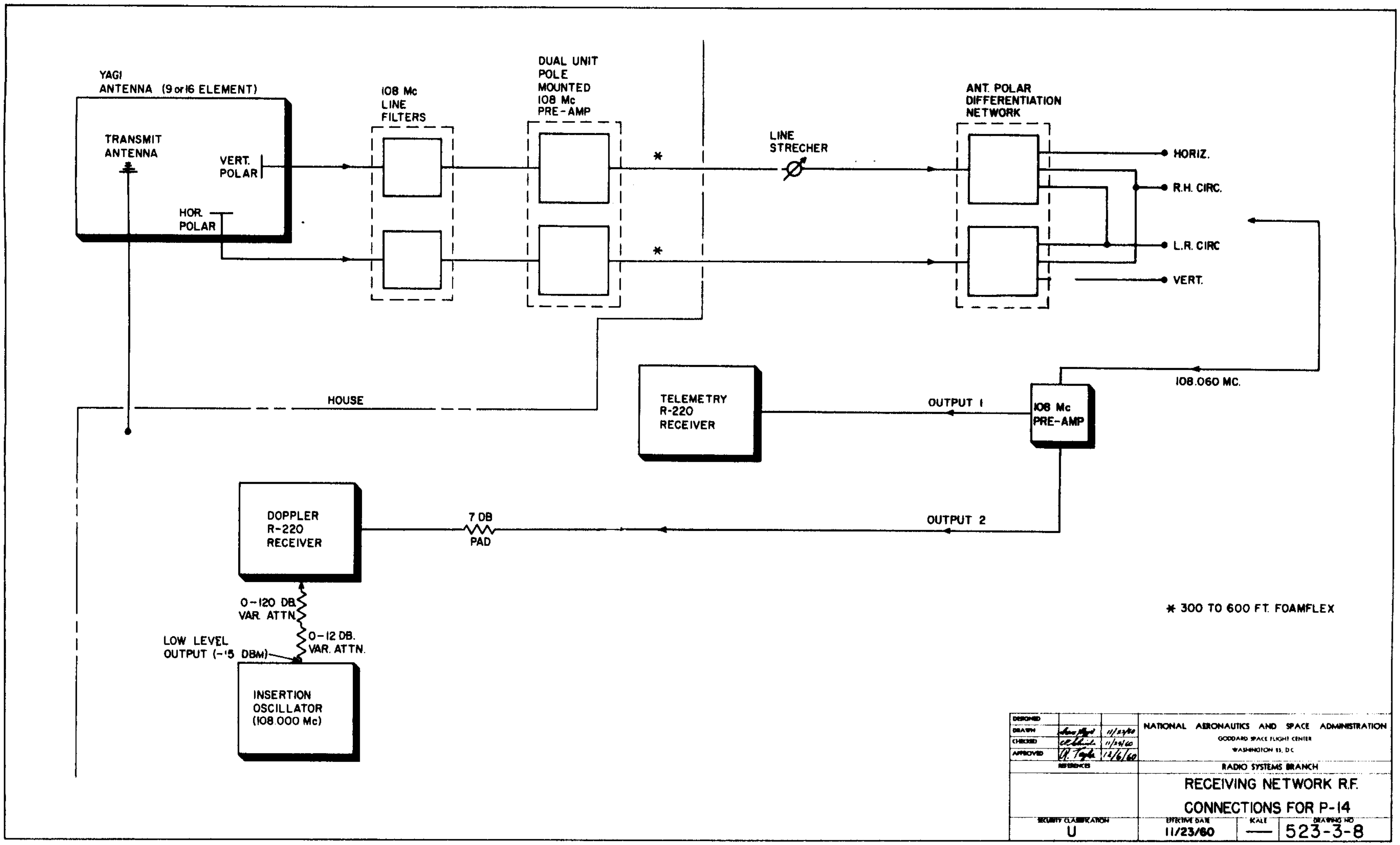


Figure 2. Receiving Network R. F. Connections For P-14

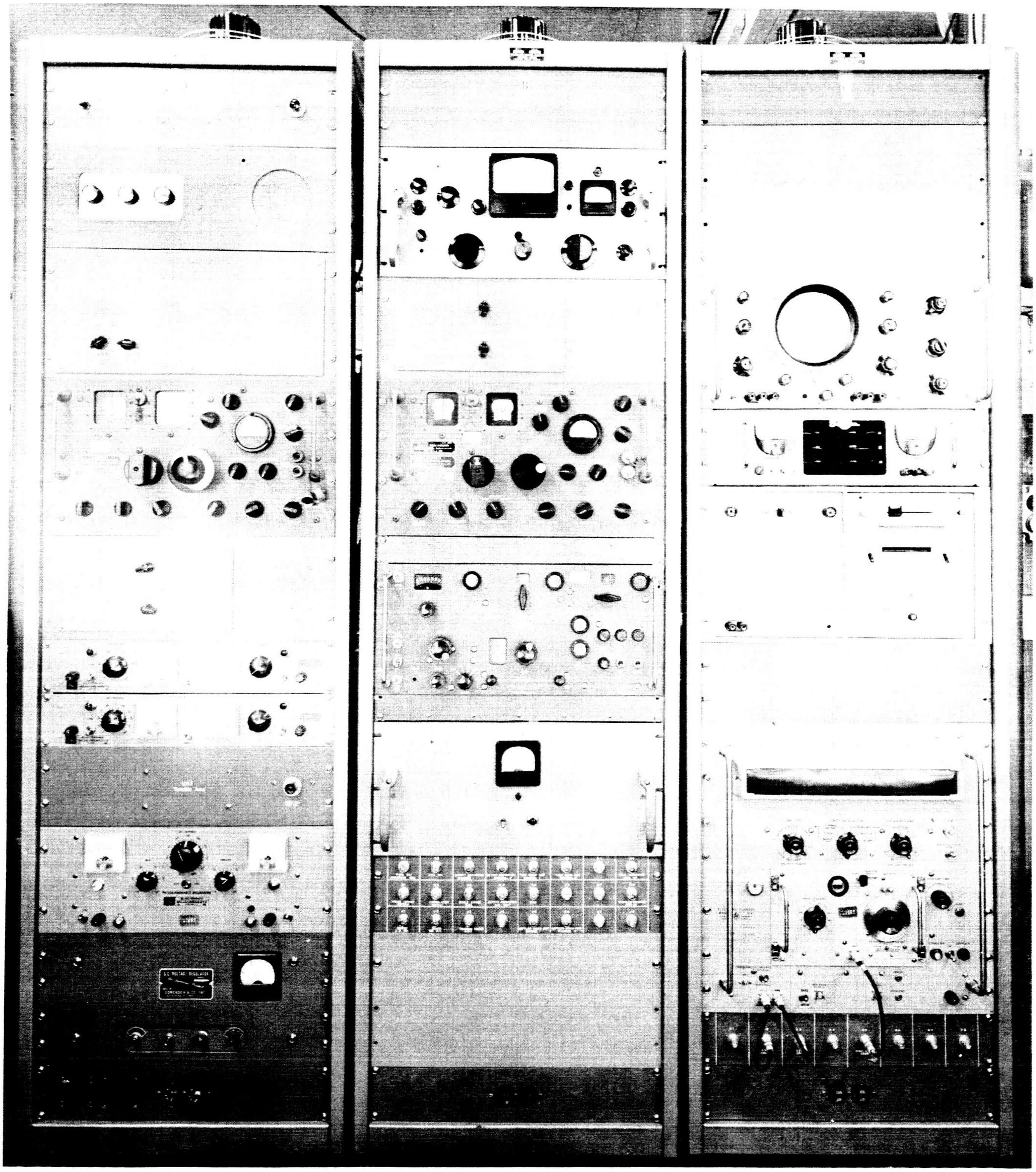


Figure 3. Photograph of P-14 Equipment (A, B and C Racks)

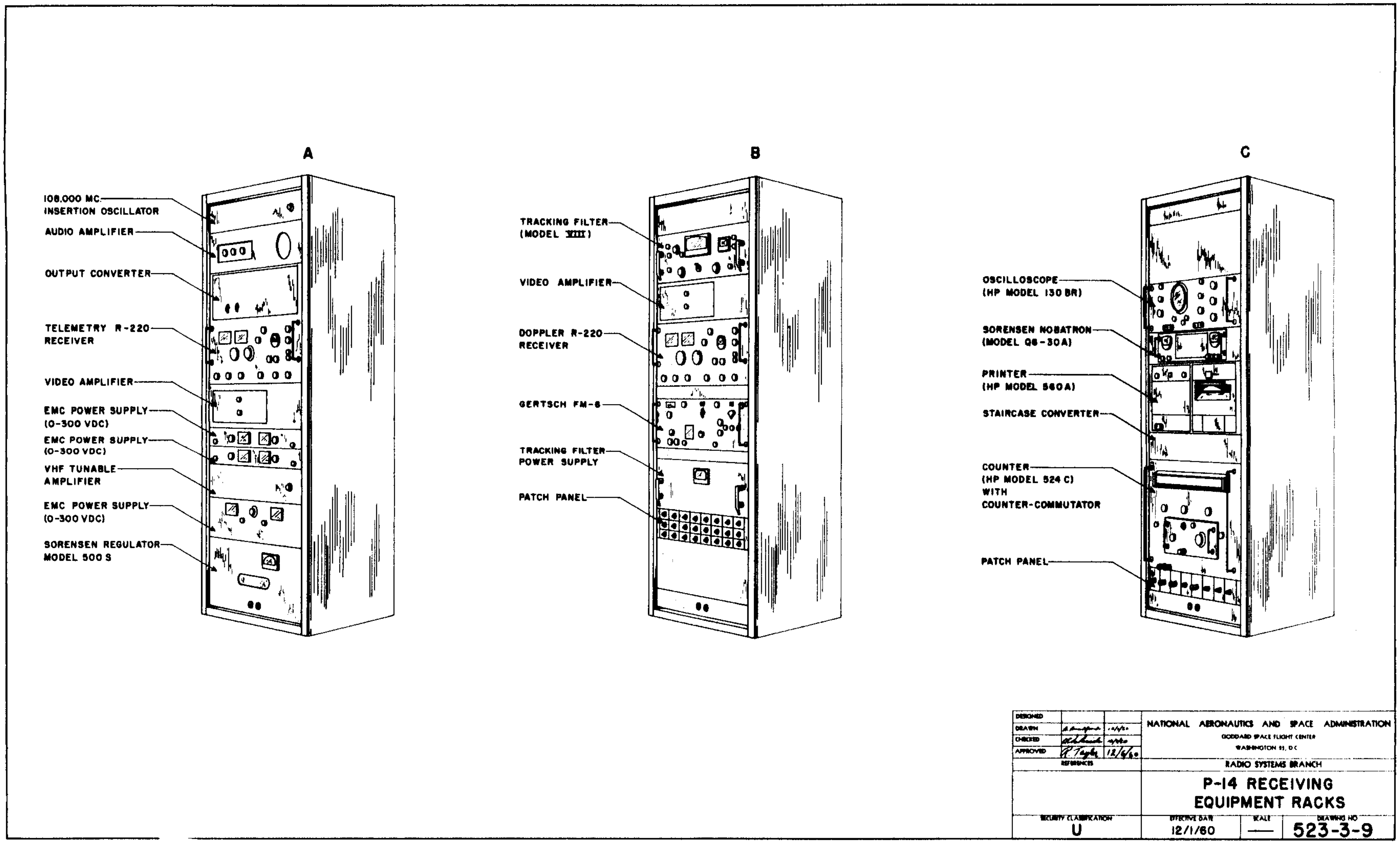
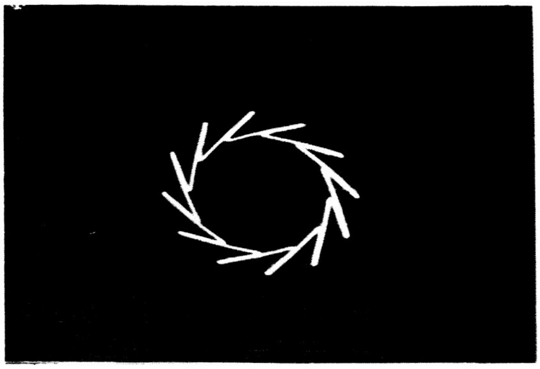
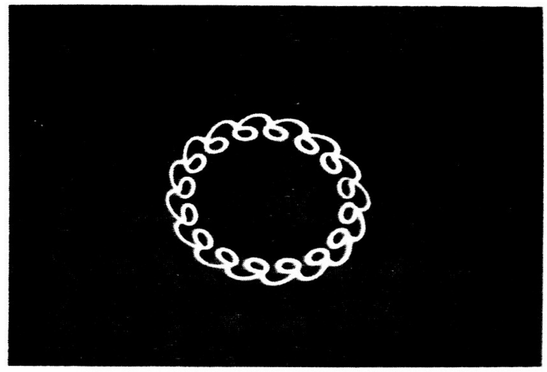


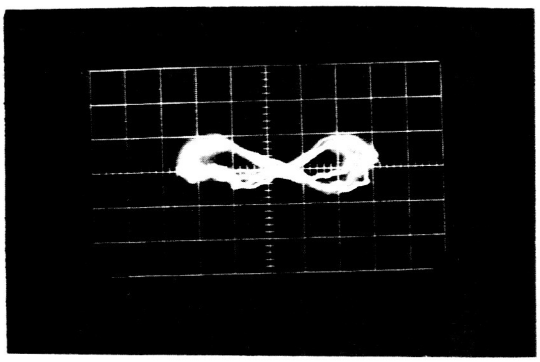
Figure 4. P-14 Receiving Equipment Racks (A, B and C)

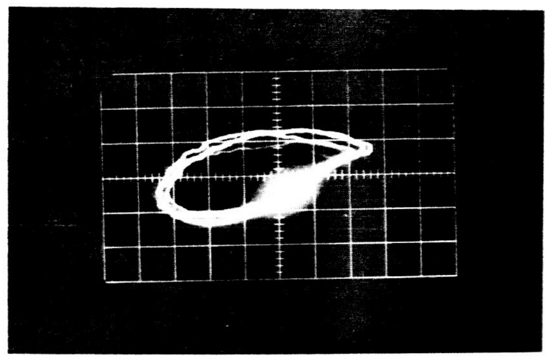
CARRIER SIDEBAND



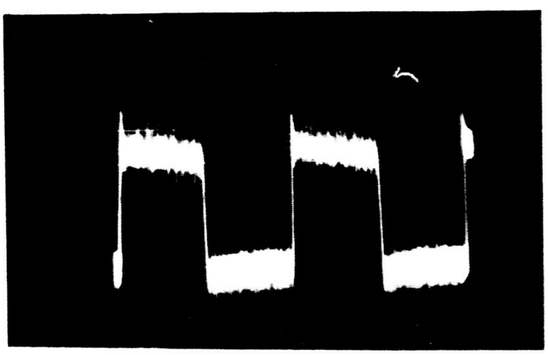


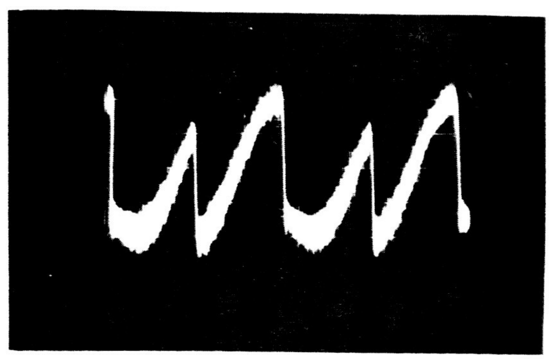
A Pre-lock (700 cps modulation) B





C Lock-on (10 cps) D





E Lock-on (1000 cps) F

PM demodulated signal

Figure 5. Lissajons and Lock-on Patterns

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